DIEL FEEDING CHRONOLOGY OF SIX FISH SPECIES IN ANCHUTHENGU BACKWATER, KERALA

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ABSTRACT

The study examined diel feeding chronology of six fish species in Anchuthengu Backwater, Kerala. Over the 24-h period, more or less same items contributed to the diet of *Arius arius.* *Mugil cephalus* exhibited substantial diel variation in diet composition, with algae forming the main dietary component in the diurnal diet, and prawns in the crepuscular and nocturnal diets. Algae and rotifers formed the main food items throughout the 24-h feeding period in *Hyporhamphus xanthopterus*. No change was noticed in the diel diet composition in *Ambassis commersonii*. While *Caranx ignobilis* showed no diel variation, *Gerrus lucidus* that feeds on a variety of prey items seemed to exhibit some diel variation in feeding. All the fish examined had diurnal feeding peaks. The results indicate that because of diel variation in diet composition and feeding periodicity for these six species, dietary analysis conducted at only one interval would not provide an accurate representation of the diet of these species.

Keywords: Dietary analysis, diel variation, feeding periodicity

INTRODUCTION

Diel feeding rhythms related to light periodicity are observed commonly among teleost fish, the food intake often being predominantly diurnal, nocturnal or crepuscular (Thorpe, 1978). Studies of diel feeding rhythms in natural population are laborious and not much field studies of feeding periodicity of natural fish populations of tropical waters are available. However, daily variations in the intensity of feeding and the components of the diet have been documented in fishes of temperate waters. Diel pattern in feeding for freshwater fishes has been documented by Keast and Welsch as early as 1968. It is only in the recent years that the diel feeding patterns of marine/estuarine fishes were started to be examined (Albert 1995; Pillar and Barange, 1995; Derbyson *et al.*, 2003). These studies demonstrated that marked differences in feeding intensity can occur throughout the day. This diel variation needs to be taken into account when investigating feeding interactions in estuarine ecosystems.

A perusal of literature on feeding in fishes of Indian waters shows that studies on the diel pattern of feeding in fishes are very rare and hence, the present attempt.

MATERIAL AND METHODS

Fishes were collected from the marine zone of the backwater, using cast net at 6-hour intervals over a 24-hour period during June 2003. Four sampling times, 6-hour apart, were chosen to assess the diel changes in feeding. Sampling was conducted at 0600, 1200, 1800 and 2400 hours. Collections were initiated about 15 minutes before the hour and were generally completed in about half an hour. Water temperature ranged from 22 to 26C. Fishes captured were anaesthetized and placed in 10% formalin to halt digestion. After each collection period, the abdomens of fish larger than 100 mm total length were slit to allow the preservative to enter the body cavity.

In the laboratory, fish were weighed and measured before their stomachs were removed and examined. The entire stomachs or the anterior third of the digestive tracts, when lacking a distinct stomach, were weighed with the contents and used for the examination later.

Diet composition for each fish species at each 6-hour interval was quantified based on the dry weight values of the food items in the stomach, obtained by drying each food item at 103C for 24 hours. Daily diet composition (*i.e.,* 24 h) was determined using weighted percent dry weight values for each food category from each of the 6-hour intervals. Feeding periodicity for each species was determined by dividing the mean dry weight of the stomach contents by the mean wet weight of the fish at each 6-hour interval (Keast and Welsh, 1968). A stomach fullness index (IF) was calculated following **Derbyson** *et al.* (2003) for each stomach to adjust for variation in fish size: IF = $10000cL^3$, where c is the stomach content mass and L is the fish length (total length). Diet overlap ($C\lambda$) between species was estimated using the equation of Horn (1966).

RESULTS

The diets of 193 fish were examined (Table 1) in the investigation that included

Table 1: Number examined, percentage of empty stomachs, total length and weight of fish collected at 6-hour intervals from Anchuthengu Backwater

Species	0600 h				1200 h			
	Number examined	Empty (%)	TL range (mm)	Weight range (g)	Number examined	Empty (%)	TL range (mm)	Weight range (g)
Arius arius	5	40.0	150-260	33.0-145.0	9	33.3	132-250	10.8-30.3
Mugil cephalus	11	34.4	140-229	32.0-67.0	8	25.0	148-175	20.8-50.4
Hyporhamphus xanthopterus	8	37.5	180-200	16.4-26.5	8	62.5	195-224	20.5-22.5
Ambassis commersonii	12	16.7	85-14	4.5-18.6	1	0	100	16.5
Caranx ignobilis	10	20.0	110-170	20.5-67.6	2	0	125-165	20.9-30.5
Gerrus lucidus	4	25.0	90-115	10.5-13.1	5	40.0	81-91	9.5-10.3

Species	1800 h				2400 h			
	Number examined	Empty (%)	TL range (mm)	Weight range (g)	Number examined	Empty (%)	TL range (mm)	Weight range (g)
A. arius	13	53.8	133-210	20-33.1	14	57.1	121-230	23.0-24.1
M. cephalus	7	57.1	140-150	26.9-32.7	4	0	135-225	24.0-87.0
H. xanthopterus	12	41.7	165-198	17.0-34.2	6	33.3	176-190	25.9-27.0
A. commersonii	17	47.0	90-123	6.8-18.5	19	15.8	83-130	7.3-20.1
C. ignobilis	5	40.0	128-174	28.5-77.6	5	60.0	140-170	65.3-68.1
G. lucidus	5	40.0	90-105	10.3-19.0	3	33.3	102-161	11.1-70.2

41 threadfin sea catfish *(Arius arius),* 30 flathead mullet *(Mugil cephalus),* 34 halfbeak *(Hyporhamphus xanthopterus),* 49 glass perchlet *(Ambassis commersonii),* 22 juvenile giant trevally *(Caranx ignobilis)* and 17 whipfin silver-biddy *(Gerrus lucidus).* Most collections exceeded five specimens of each species at each 6-hour interval.

The results of food analyses of fish species over the 24-hour period are given in tables 2 and 3. Prawn remains constituted 24.1% of the gut contents of *A. arius.* Various crustaceans (18.8%), aquatic insects (17.4%), fish parts (16.9%) and rotifers (16.5%) were almost equally represented in the diet of the species. Among the gut contents, various algae constituted 28.2% in *M. cephalus diet.* Copepods and other crustaceans constituted 12%, and the remains of fish and prawn also occurred in fairly good proportions. Diatoms, desmids and rotifers were the major prey (73.5%) of *H.*

Table 2: Percentage dry weight of prey items in the diet of the six species at 24-hour total

Prey	24-h total					
	AA	MC	HX	AC	CI	GL
Algae	5.7	28.2	43.6	52.3	56.5	32.3
Desmids	-	-	5.1	-	-	1.4
Plants	-	18.7	-	-	-	3.2
Rotifers	16.5	-	24.8	-	14.6	21.7
Polychaetes	-	3.8	-	-	-	6.9
Crustaceans	18.8	12.0	9.1	-	12.2	5.1
Insect remains	17.4	-	7.8	7.4	4.4	13.3
Chironomid larvae	-	5.1	-	-	-	-
Prawn parts	24.1	21.5	-	-	-	8.0
Molluscs	-	-	-	14.1	-	-
Fish remains	16.9	10.7	5.0	13.1	12.3	8.1
Detritus	0.6	-	4.6	13.1	-	0.1

Table 3: Percentage dry weight of prey items in the diet of the six species at 6-hour intervals

Prey	0600 hour total								1200 hour total					
	A	C	X	C	I	L	S	M	A	C	X	C	I	L
Algae		9.1	9.7	8.0	7.8	0.5	5.1	7.7	0.6	4.9	2.2	5.4	2.0	3.4
Desmids			2.0				0.5							
Plants						2.9	1.1	0.6						
Rotifers	7.8		8.3		5.9				7.6		6.4			8.6
Polychaetes		0.6				7.5								
Crustaceans	1.0	6.2			7.9		6.3	9.7	7.6	6.9	3.1		3.1	
Insect remains	0.9					7.4			5.8					6.2
Chironomid larvae										6.5				
Prawn parts	2.5					1.7			4.0					
Molluscs				2.2								0.4		
Fish remains	0.8	1.1		7.8	0.4				9.4	1.7	8.3		0.9	1.8
Detritus				3.0								4.2		

Prey	1800 hour total								2400 hour total					
	A	C	X	C	I	L	S	M	A	C	X	C	I	L
Algae	7.3	0.6	1.1	2.2	0.8	4.4	5.5	0.5		4.3	1.2	3.6	5.4	0.8
Desmids						0.7	6.9							
Plants		4.4						0.5		0.5				
Rotifers	0.6		1.6		1.1	9.2		0.8			1.3		1.4	8.8
Polychaetes		0.5												
Crustaceans	8.9	4.8	,0.4		7.6				7.6		8.7			0.3
Insect remains	0.6		1.2	0.7					3.2			0.9	7.6	
Chironomid larvae														
Prawn parts	0.8	0.7						9.6	9.9	5.2				
Molluscs												0.9		
Fish remains	0.8		0.7	3.4	0.5	0.7			0.7			1.2	0.6	0.1
Detritus				0.7			7.6	7.6	0.6		8.8	0.4		

xanthopterus. The other food items in the order of abundance were crustaceans (9.1%), insect parts (7.8%), fish remains (5.0%) and detritus (4.6%). The main food of *A. commersonii* during the 24-hour study was found to be algae. Molluscan parts (14.1%), fish remains (13.1%) and detritus (13.1%) were also about equally represented in the diet of *A. commersonii*. While rotifers, crustaceans and fish remains constituted 14.6, 12.2 and 13.1%, respectively, in the gut contents of *C. ignobilis*, algae dominated and formed 56.5%. *G. lucidus* fed more on algae (32.3%) and rotifers (21.7%). Excluding chironomid larvae and molluscs, the gut of *G. lucidus* contained all other types of available food items in the ecosystem.

The six species exhibited different patterns of food consumption over the 24-hour period. All the species showed diural feeding peak, with food consumption peaking at 1800 hours (Fig. 1; Table 4). *A. arius* had low feeding at

Table 4: Diel variation in Stomach fullness index calculated for each species

Species	6 h	12 h	18 h	24 h
A. arius	5.7489	5.1722	13.6328	7.7967
M. cephalus	6.8231	1.5093	10.0026	1.7693
H. xanthopterus	3.6320	1.9899	4.5556	3.7038
A. commersonii	12.4659	4.1100	23.2550	5.9406
C. ignobilis	13.3581	6.5142	13.1409	7.7450
G. lucidus	27.3346	11.9723	32.6652	11.6365

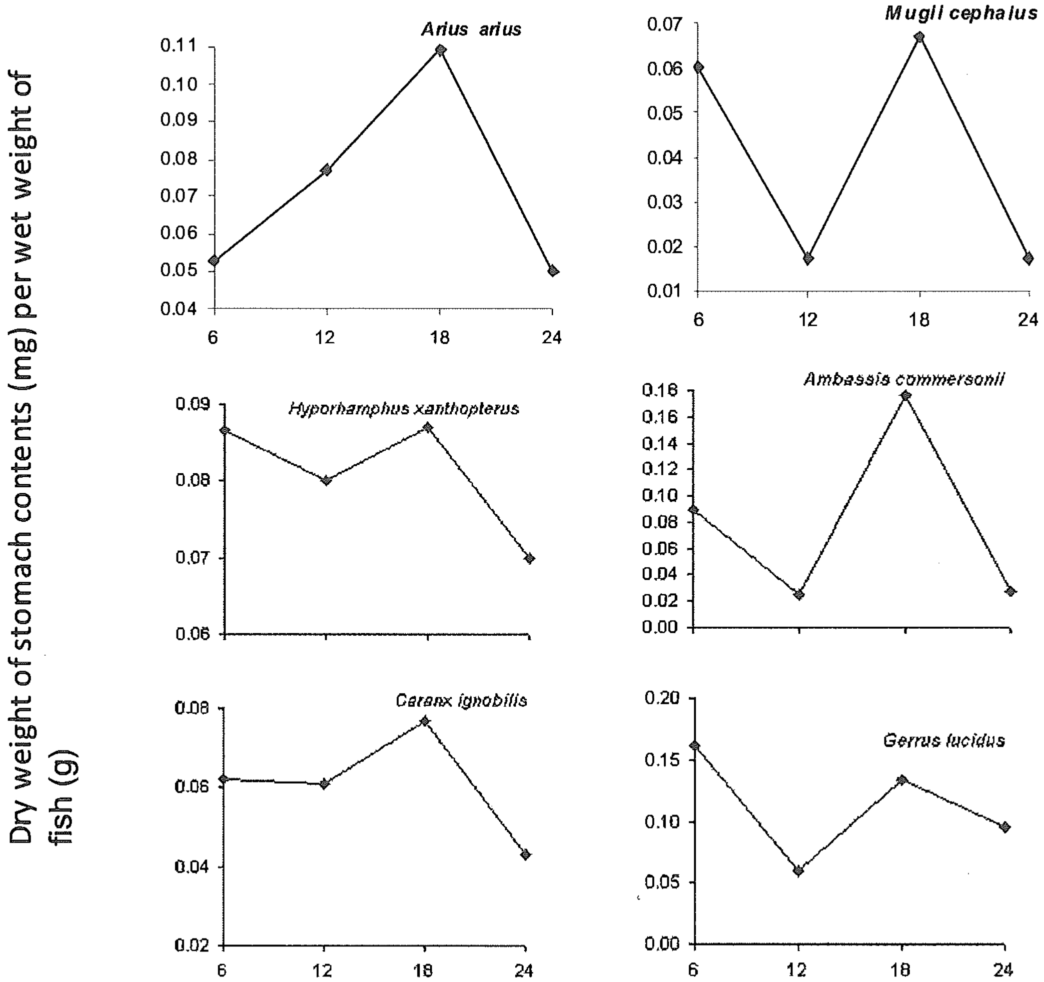

Fig. 1: Feeding periodicity of six species of fish collected from Anchuthengu backwater

Table 5: Average diel diet overlap between species

Fish comparison		Overlap
HX	CI	0.9393
HX	GL	0.9248
AC	CI	0.8923
CI	GL	0.8389
HX	AC	0.8126
AC	GL	0.7235
MC	GL	0.6908
MC	CI	0.6646
AA	GL	0.6420
MC	AC	0.6166
MC	HX	0.6004
AA	MC	0.5810
AA	HX	0.4610
AA	CI	0.3880
AA	AC	0.2540

0600 and 2400 hours, and fed moderately at 1200 hours with a peak at 1800 hours. *M. cephalus* showed the highest level of feeding activity at first light and at the end of the light phase, with a marked reduction in feeding in the afternoon. *H. xanthopterus* fed heaviest during the day and food consumption was minimal at night. *A. commersonii* showed marked diel functions, with intense feeding at the end of the light phase. Food consumption was moderate during the early hours and was minimum at 1200 and 2400 hours. The feeding of *C. ignobilis*, like *H. xanthopterus*, was mostly by day with a maximum at dusk and feeding was low at night. *G. lucidus* exhibited the highest stomach fullness during the early hours and moderate feeding at other times.

Diel diet overlap was high (0.6) in four out of the 15 fish combinations (Table 5). The maximum overlap in diel diet was noticed between *H. xanthopterus* and *C. ignobilis,* and minimum between *A. arius* and *A. commersonii*. Interspecific diet overlap was low (0.6) between *A. arius* and all the other species (except with *G. lucidus*). Substantially lower overlap was recorded between *A. arius* and *A. commersonii.*

DISCUSSION

All the species of fish examined in the study exhibited feeding periodicity in Anchuthengu backwater. Diel variation in diet composition was also noticed. It is unlikely that diurnal, crepuscular or nocturnal sampling alone would accurately reflect the diel diet composition on feeding periodity.

Crustaceans, insects, prawns and fishes dominated the diet of *A. arius* in the study. This is consistent with the previous reports. Earlier, dietary analysis of the species (Rohini, 2001) from the same environment showed the fish to feed on a variety of organisms that include polychaetes, insects, molluscs, prawns, fish remains, plant matter, detritus and miscellaneous items. Fish remains formed the major portion of the diet. Variation in preference for particular food(s) as a function of size has also been noticed; lower size groups consuming polychaetes, crustaceans, prawns and molluscs, and larger group mostly preferring fish and detritus. In the present study, it was seen that over the 24-hour period more or less the same items contribute to the diet; the only difference was in the quantity consumed.

Mullet have been described variously by different workers as algal feeders, iliophagous, detritus feeders on micro- and meio- benthos, deposit feeders, interface feeders and soft-bottom feeders (Brusle, 1981). Being a dominant brackishwater group, the food and feeding aspects of different species of mullet have received much attention in India. Luther (1962) inferred that the main food of *M. cephalus* off Mandapam waters is constituted by decaying organic matter and foraminiferans supplemented by diatoms, algae and occasionally decapods. Studies by Das (1977) revealed that the food of *M. cephalus* in Goa waters is composed of decaying and decomposing algae, diatoms, copepods and foraminiferans. The main food of *M. cephalus* in estuaries, according to Blaber (1976), is small gastropods, larger foraminiferans, centric diatoms, smaller diatoms and detritus. In the present study, the diet was composed mainly of algae, copepods, prawns and fish remains, probably from the substrate. While the fish takes in mostly algae and crustaceans in the diurnal diet (0600 and 1200 h), prawn fragments of different size formed the nocturnal diet. The highest occurrence of prawns in the diet, late in the day (1800 h), indicates a switch to particle feeding when prawns are more active. Studies on feeding rhythms of mullet are absent, hence comparisons are not possible.

Studies on the feeding ecology of hemirhamphids consider them as partial herbivores (Blaber, 1997). Aquatic macrophytes form the predominant food of *H. capensis*, but switch to animal diet (mainly amphipods and isopods) when plants are scarce (Coetzee, 1981). *H. melanochir* is reported as a diurnal herbivore and nocturnal carnivore by Robertson and Klumpp (1983). Certain other *Hyporhampus* spp. feed almost entirely on aquatic macrophytes as adults. Their juveniles consume mainly planktonic animals. In the present study, algae, rotifers and planktonic crustaceans formed the main food items of *H. xanthopterus* throughout the 24-hour feeding period.

Ambassids are reported as zooplankton feeders of the estuarine system as most species feed on organisms such as cladocerans, ostracods, copepods, insects and small fish in the water column or from the surface. According to Coates (1990), insect larvae and insects from the surface of the water as well as ostracods and cladocerans form the main food of *A. interruptus*. Some species in East African estuaries are reported as primarily zooplanktivores taking mainly crustaceans. Species occurring near the mouth of estuaries subsist on a narrow food spectrum and others on a broader diet. Planktonic algae, insects and fish remains (larvae and post-larvae) formed the food of *A. commersonii* in the present study. Some of this variability in the diet of ambassids reflects the differences in prey availability. No change in diet composition was noticed in the present samplings; the only difference was in the quantity of food taken in by the species.

Fish and zooplankton contributed mainly to the diet of *C. ignobilis* in the backwater. Here too, diel variation in diet composition has not been noted. As per Blaber (1997), juveniles and sub-adults of *Caranx* spp. in tropical estuaries feed on smaller fishes; but in turbid system, they are not among the major piscivores.

A variety of prey items were detected in the gut of *G. lucidus*, which included diatoms, desmids, plant bits, rotifers, polychaetes, and the remains of crustaceans, insects and prawns. They might be feeding on or just below the surface of the substratum. As per Prabhakararao (1968), polychaetes form the single most important food of gerrids in India. With regard to the diet composition, there seems to be some diel variation that is difficult to comment upon with this study.

Diet overlap among the six fish species was high, indicating the general absence of partitioning of food resources among these species. Only one species, namely *A. arius,* exhibited low overlap values that do not exceed the suggested level of significance (0.60) when considering ecological overlap (Zaret and Rand, 1971).

The study, thus, revealed that the diet composition varies with the feeding rhythm in most fishes. Therefore, for a full understanding of the relative significance of any feeding specialisation, it is necessary to have the information of diel feeding.

Diel pattern of food consumption differed among the species selected for the investigation. Food consumption of *A. arius* increased substantially from 0600 hours, peaking at 1800 hours. *M. cephalus* had diurnal feeding at 0600 and 1800 hours, while lower feeding was recorded at mid-day and night. This differed from the report of Day *et al.* (1981), where the fish is said to feed mainly in the evening and continue at a slower rate at night. *H. xanthopterus* consumes more food during the day-light hours than at night. Feeding rate is higher during the day time in *C. ignobilis* which can be accounted to the visual feeding nature of the species as Day *et al.* (1981) pointed out. The other four species also showed feeding peaks at 1800 hours. As studies of diel feeding ecology of tropical fishes are not many, comparisons are difficult to make. Hence, further standardized studies are needed in this line using fishes in these waters.

Earlier studies of feeding rhythms have reported strong diel patterns of feeding in fishes. Detailed investigations carried out using temperate species indicate that control of feeding time is not regulated necessarily by natural variations in food availability (Boujard and Leatherland, 1992). Feeding patterns were likely to be entrained to diurnal variation with light and/or temperature. The choice of feeding time in fish may be influenced not only by endogenously generated rhythms, but perhaps also by temporal variation in the intensity of competition. Intra-specific differences in the ability of individual fish to compete for resources also play a role (Kadri *et al.*, 1997).

The results of the study indicate that since both the intensity of feeding and the composition of the diet vary greatly between night and day, the data used to calculate the daily ration of a fish should not be based solely on time of the day, but should span a 24-hour period. Thus, diel variation needs to be taken into account when investigating feeding interactions in fishes.

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